PRODUCTIVITY IMPROVEMENT VIA SIMULATION IN MANUFACTURING INDUSTRY

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ABSTRACT

Productivity improvement effort such as better layout arrangement, minimize the total production cost or maximize the throughput had been given great attentions in today manufacturing industries. However, to execute such improvements involve a big amount of money which normally be the cause that obstruct the improvements. Simulation has become one of the solutions to this problem and rapidly gaining the industry confident nowadays. This study aims to make improvement in terms of the company's production layout which focusing to the sandwich bread production line. The study is conducted at Roti Temerloh Enterprise, a company which produces products such as sandwich breads, buns and cakes. Being considered as one of the Small and Medium Enterprises (SMEs), cost certainly be the big issues when improvement planning to be considered. Using WITNESS simulation software, the production of the sandwich bread will be modeled and some adjustment then reviewed through the simulation to come up with the improved alternatives layouts. Comparison analysis is carried out and the results show in increased of production up to 265 breads per day for alternative 1 and 581 breads per day for alternative 2 and 3. Machine utilization in term of idle time, busy time and blocked for; Alternative 1 86.69%, 13.49% and 0.49%, Alternative 2 66.49%, 26.82% and 6.69%, Alternative 3 69.64%, 25.04% and 5.32%. From the cost effectiveness analysis, the cost is RM2.06 per unit for Alternative 1 and RM1.49 per unit for Alternatives 2 and 3. Thus the suggested alternative is Alternative 3.

ABSTRAK

Peningkatan produktiviti seperti pengubahsuaian susun atur premis, pengurangan kos atau memaksimumkan pengeluaran telah diberi perhatian yang penting dalam industri pembuatan masa kini. Akan tetapi, keperluan kewangan yang tinggi sering manjadi penghalang bagi melakukan perubahan tersebut. Disebabkan itu, penggunaan simulasi semakin diterima secara meluas bagi menyelesaikan masalah tersebut. Tujuan kajian ini adalah untuk membuat penambahbaikan dalam barisan pengeluaran roti sandwich di Syarikat Roti Temerloh yang menghasilkan produk-produk seperti roti sandwich, bun dan kek. Bagi pengusaha kecil dan sederhana, faktor kos sememangnya diambil berat dalam melaksanakan sebarang perubahan. Proses pengeluaran roti sandwich sedia ada akan dimodel menggunakan perisian simulasi WITNESS, dan tiga alternatif baru dicadangkan. Analisis perbandingan menunjukkan jumlah pengeluaran sebanyak 261 unit sehari bagi Alternatif 1 dan 581 unit sehari bagi Alternatif 2 dan 3. Peratus penggunaan mesin dari segi waktu senyap, waktu sibuk dan sekatan dalam proses bagi; Alternatif 1 adalah 86.69%, 13.49% dan 0.49%, Alternatif 2 66.49%, 26.82% dan 6.69%, Alternatif 3 69.64%, 25.04% dan 5.32%. Kos penghasilan produk bagi Alternatif 1 ialah RM 2.06 seunit manakala bagi Alternatif 2 dan 3 kosnya adalah RM 1.49. Maka Alternatif 3 dipilih sebagai alternatif terbaik untuk dicadangkan.

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LIST OF ABBREVIATIONS

AGV	Automated Guided Vehicle
DES	Discrete Event Simulation
DoD	Department of Defend
HVAC	Heating, Ventilation, and Air Conditioning
IIE	Institute of Industrial Engineers
M&S	Modeling and Simulation
MEE	Manufacturing Enterprise Engineering
MRS	Manufacturing Related Services
MTM	Method Time Measurement
OR	Operations Research
PCB	Printed Circuit Board
R&D	Research and Development
SEE	Service Enterprise Engineering
SME	Small and Medium Enterprise

CHAPTER 1

INTRODUCTION

1.0. INTRODUCTION

Manufacturing industry play an important role in providing all the things needed in human daily life. Many types of products through various processes are involved to create product from raw materials. All parties involved in this industry struggling to come out with a new and improved ways to fulfill the market need. However, money is always be the main obstacle in making necessary improvement as better improvement might require advance tools to identify the improvement needed and much more to implement the new improved methods. In such cases, simulation is one of the preferred ways to meet the desire in making essential improvement with minimum funds.

There are a few examples of researches which had been conducted using simulation as a method to conduct and evaluate their study. Brown and Sturrock (2009) used simulation to model multiple process improvement opportunities for a HVAC manufacturer in order to reduce facility's operating cost. The study results in cost reduction by minimizing inventory, eliminating over-time labor and increase throughput.

Dengiz (2009) was able to obtain 46.63 percent of the total cost reduction of the printed circuit board (PCB) production system for the alternative system with optimal working conditions obtained from the optimization of simulation. Another example is the productivity improvement in drill collar manufacturing process by

Vasudevan et. al. (2009) which recommended an improvement of productivity by 47% which contribute to the approximated annual revenue increase of $1,800,000.

The simulation capabilities to produce alternatives solution to the current problem by using given data which suites the problem makes it preferable tool as no other cost involved compared to research conduct on site. Comparing few layouts suggested, reducing idle time, redesign assembly line are much simpler to be conducted through the use of simulation. Riddick and Lee (2008) stated that here are many potential simulation applications that might make use of layout information, such as simulations looking at ergonomic issues, material handling issues, or comparisons of the effects of different layouts on production operations. Simulation can provide an effective means to evaluate many different alternatives involving layout issues, without incurring the cost and effort of physically modifying existing facilities.

1.1. PROBLEM STATEMENT

Small and Medium Enterprises (SMEs) has an important role in supporting growth of Malaysian economic development. In the 2012 budget announced by the Prime Minister, it contributes almost 31 percent of KDNK, 56 percent of work force and 19 percent of the total export. Many incentives and programs being run by the government to generate the improvement of SMEs. For example in the 2012 budget, the government announcing the SME Revitalization Fund which worth RM100 million which offers loans to the entrepreneur with maximum amount of RM1 million to re-established their business which affected by the economic crisis and the cost increment.

Despite all the incentives offers by the government, some of the SMEs participants are facing challenges which can bring their business down. According to Saleh and Ndubisi (2006), among the challenges are the low level of technological capabilities and limited skilled human capital resources, a low level of technology and ICT penetration, low levels of research and development (R&D), a substantial orientation towards domestic markets, a high level of international competition (for

example, from China and India), a high level of bureaucracy in government agencies, and internal sourcing of funds.

Focusing to the technologies capabilities problem, many SMEs participant are still bind to their old ways in manufacturing their product. The usage of traditional methods and facilities has made their business failed to compete with the others big company with advanced method. Narrowing the problem down to their production floor layout it seemed that their design of layout sometimes just being prepared according their own desires without any details consideration of the production productivity involved throughout the process.

This research aim is to make use of the simulation methods provided nowadays in making productivity improvement in manufacturing fields. With the use of WITNESS simulation software, the improvement was made by focusing to the current layout used and come out with several other alternatives. Cost production also considered in choosing the best alternative.

1.2. OBJECTIVES

The objectives of this project are:

1.2.1. To identify and evaluate the problems in existing production floor layout.
1.2.2. To design and improve manufacturing production layout by using simulation software and observation during the collection data of cycle time.
1.2.3. To propose the best layout improvement with the lowest cost involved.

1.3. SCOPE OF THE STUDY

The scopes of the study are:

1. This study took place at Roti Temerloh Company.
2. Concerned in the production layout design.
3. One production line involved; which is the sandwich bread production line.
4. Data analyze and run using WITNESS Simulation software.
5. This study only recommends the best alternative layout design with lowest production cost without further implementation towards the existing design.

1.4. IMPORTANCE OF THE STUDY

Due to lack of knowledge of the production layout many SMEs just applied trial and error process in determining their company's layout. As the result, there are several problems such as bottleneck and overlapping occurred. This kind of problems can affect their production process and exposed them to great losses in business. From this project, it will at least help the SMEs participant to get better layout arrangement with the help of simulation tools used which hopefully will also increase their productivity.

1.5. EXPECTED OUTCOMES

From this study, it is hope that it will result in some good improvements based on the proposed alternative layout compared to the existing one and can benefits the SMEs industries in term of improving their productivity.

1.6. REPORT ARRANGEMENT

This study is divided into five chapters. In the first chapter, the introduction of the study is discussed. This chapter provides the problem statement of the study and the objectives of the study are stated. Some information about the scopes of study is reviewed. The importance of the study then stressed the used and importance of simulation in suggesting better production layout towards company productivity. Lastly, the expected outcomes of the study also stated in this chapter.

Chapter two provides an academic review of simulation study in manufacturing industry. This chapter starts defining key terms which are productivity and simulation and small and medium enterprises in general. Under the simulation general definition, the simulation method is mentioned, which briefly described the steps taken in building a good simulation. Further, some areas where simulation is applied are stated. The advantages and disadvantages of simulation method are revealed. Lastly, reviews of previous study that have been conducted in manufacturing industry discussed briefly.

Chapter three provides a discussion of methodology taken to execute this project from the start until the end of. This chapter begins with design of project study, where the methodology used in conducting this project is discussed. Then, discussion of data collection and simulation study is discussed in general. Some of the information regarding standard procedure, process flow, time study and cycle time are included in this chapter.

Chapter four consists of the results from the simulation process done. The results then presented in the table provided which includes the production output and the machine utilizations for each alternatives suggested. From that the cost analysis is done for each alternative and the cost per unit for each alternative is obtained. A discussion on the selection of which alternatives is the best to suggested also included in this chapter.

Chapter five is the last chapter in this report which concludes all the results obtained from the study which must be achieved based from the objective of the study. Some recommendations also given as an improvement for the study to be perform in future.

CHAPTER 2

LITERATURE REVIEW

2.0. INTRODUCTION

This chapter elaborates all the relevant keywords in this title project. The keywords were given its definitions from various perspectives and some other importance parameters such as its importance, advantages and disadvantages, tools and methods, and any other elements that are considered appropriate to be suite together. Besides explaining those keywords, some of the past researches and journals which related to this project were included and presented briefly afterwards.

2.1. PRODUCTIVITY

According to Rogers (1998), productivity is defined as the ratio of output to input for a specific production situation. It is can either refers to the cost production, labor or working time during the process of production. The more effective in planning the process can help contribute to increase the productivity in various elements.

Productivity as defined by Forbes and Ahmad (2011) is the measure of how well resources are brought together in organizations and utilized for accomplishing a set of goals. Productivity reaches the highest level of performance with the least expenditure resources. Productivity is measured as the ratio of outputs to inputs.

Berman (2008) views productivity from its standard usage which refers to the level of output-amount of services delivered, given a certain level of inputs. If an agency increases outputs without requiring more inputs or if it maintains the same level of outputs after reducing inputs, then that agency has increased in productivity.

Based from these definitions, if a productivity improvement is to be applied a company or agency needs to find the ways to maximize their number of productions with same of minimal resources, fully utilized their working time and workers. An example in describing the importance of productivity improvement is as stated by Clements (2000). With 70-90% of the cost running an organizations consisting of the salaries of the workforce, small increase in worker productivity can reap high financial return. From this example, not only the organization cost can be reduced, the profit gained in becoming future can also be increased significantly.

2.2. SIMULATION

Simulation has been used in studying all disciplines. General review on how simulation works is stated by Banks (2009). To engage modeling and simulation, students must first create a model approximating an event and then followed by simulation, which allows for the repeated observation of the model. After one or many simulations of the model, a third step takes place and that is analysis. Analysis aids in the ability to draw conclusions, verify and validate the research, and make recommendations based on various iterations or simulations of the model.

Simulation is defined as “the process of designing a model of a real system and conducting experiments with this model for the purpose either of understanding the behavior of the system or of evaluating various strategies (within the limits imposed by a criterion or set of criteria) for the operation of the system (Shannon, 1975).

Based on White and Ingalls (2009), simulation involves creating a model which imitates the behaviors of interest; experimenting with the model to generate observations of these behaviors; and attempting to understand, summarize, and/or generalize these behaviors. In many applications, simulation also involves testing and comparing alternative designs and validating, explaining, and supporting simulation outcomes and study recommendations.

Another definition of simulation by Banks (2009) refers simulation as an applied methodology that can describe the behavior of that system using either a mathematical model or a symbolic model. Simply, simulation is the imitation of the operation of a real-world process or system over a period of time. Definitions of simulation range from:

a) A method for implementing a model over time.
b) A technique for testing, analysis, or training in which real-world systems are used, or where real-world and conceptual systems are reproduced by a model
c) An unobtrusive scientific method of inquiry involving experiments with a model rather than with the portion of reality that the model represents
d) A methodology for extracting information from a model by observing the behavior of the model as it is executed
e) A nontechnical term meaning not real, imitation (the correct word here is the adjective simulated)

2.2.1. Simulation Method

Law (2006) in his paper discussing the way to develop a valid and credible simulation models, includes a seven-step approach for conducting a successful simulation study. This steps are important things to be reviewed as one common argument regarding simulation is does the simulation can actually simulate the real problems and validated. Validation is the process of determining whether a simulation

model is an accurate representation of the system, for the particular objectives of the study (Law, 2006). All these seven step approach pointed by Law are listed as followed:

Step1. Formulate the Problem

Problem of interest is stated by the decision maker. It may not be stated precisely or in quantitative terms. An iterative process is often necessary. A kickoff meeting(s) for the simulation project is (are) conducted, with the project manager, the simulation analysts, and subject-matter experts (SMEs) in attendance. The following things are discussed at this meeting:

a) The overall objectives for the study
b) The specific questions to be answered by the study (without such specificity it is impossible to determine the appropriate level of model detail).
c) The performance measures that will be used to evaluate the efficacy of different system configurations.
d) The scope of the model
e) The system configurations to be modeled
f) The time frame for the study and the required resources (people, computers, etc.).

Step2. Collect Information/Data and Construct Assumptions Document

Step two consists of collect information on the system layout and operating procedures. Data collected to specify model parameters and probability distributions (e.g., for the time to failure and the time to repair of a machine). Document the model assumptions, algorithms, and data summaries in a written assumptions document (sometimes called a conceptual model). The level of model detail should depend on the following:

a) Project objectives.
b) Performance measures of interest.

c) Data availability.
d) Credibility concerns.
e) Computer constraints.
f) Opinions of SMEs.
g) Time and money constraints.

There should not be a one-to-one correspondence between the model and the system. Then, collect performance (output) data from the existing system (if any), to be use for model validation in Step 5.

Step3. Is the Assumptions Document Valid?

Perform a structured walk-through of the assumptions document before an audience that includes the project manager, analysts, and SMEs. Within the DoD community, this is sometimes called conceptual-model validation. If errors or omissions are discovered in the assumptions document, which is almost always the case, then the assumptions document must be updated before proceeding to programming in Step 4.

Step4. Program the Model

Program the assumptions document in a commercial simulation-software package or in a general purpose programming language (e.g., C, C++, and Java). Verify (debug) the computer program.

Step5. Is the Programmed Model Valid?

If there is an existing system, then compare simulation model output data for this system with the comparable output data collected from the actual system (see Step 2). This is called results validation. Regardless of whether there is an existing system, the simulation analysts and SMEs should review the simulation results for reasonableness. If the results are consistent with how they perceive the system should operate, then the

simulation model is said to have face validity. Sensitivity analyses should be performed on the programmed model to see which model factors have the greatest impact on the performance measures and, thus, have to be modeled carefully.

Step6. Design, Conduct, and Analyze Experiments

For each system configuration of interest, decide on tactical issues such as run length, warm up period, and the number of independent model replications. Analyze the results and decide if additional experiments are required.

Step7. Document and Present the Simulation Results

The documentation for the model (and the associated simulation study) should include the assumptions document (critical for future reuse of the model), a detailed description of the computer program, and the results of the current study. The final presentation for the simulation study should include an animation and a discussion of the model building/validation process to promote model credibility.

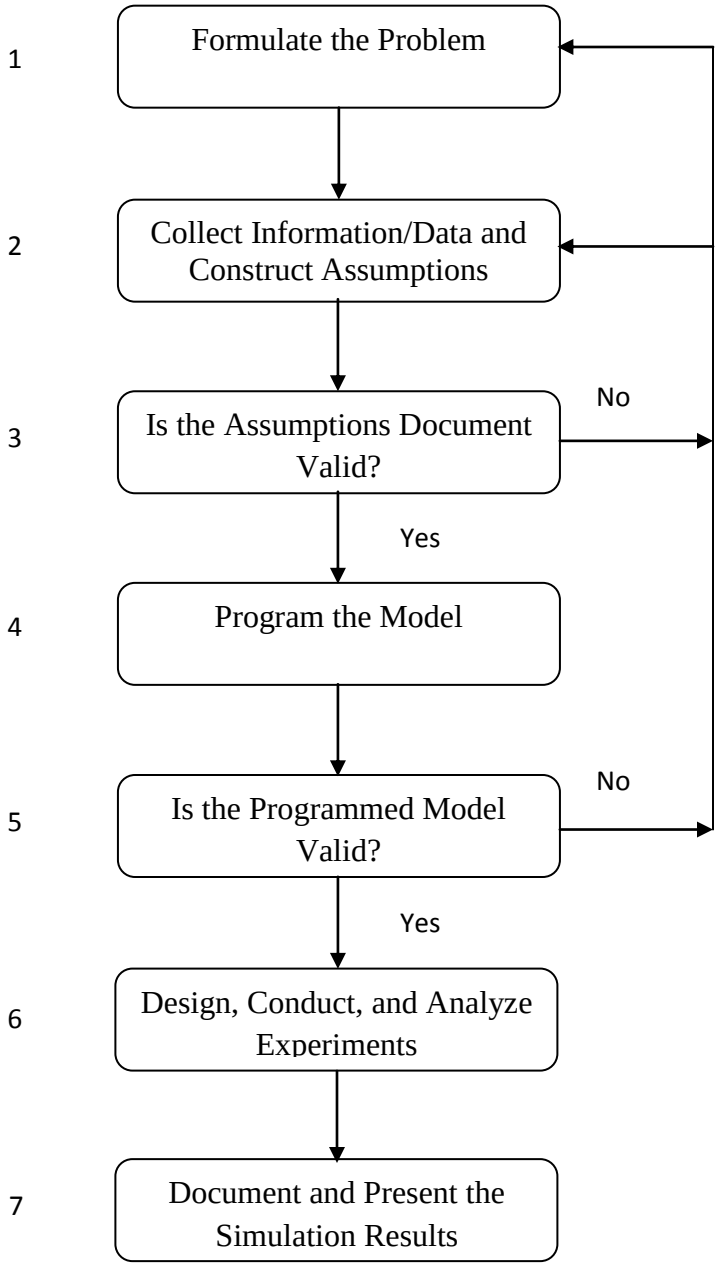

Figure 2.1: A Seven-Step Approach for Conducting a Successful Simulation Study (Law, 2006)

2.2.2. Areas of Application

The area of application for simulation is not restricted to certain field only. The fact that it can be used at any time without interfering with the current and real system makes it applicable in many fields. These are some of the areas where simulations are applied which has been sorted from Banks (2009):

a) Military usage - M&S applications are used primarily for analysis, experimentation, and training. Analysis refers to the investigation of the model's behavior. Experimentation occurs when the behavior of the model changes under conditions that exceed the design boundaries of the model. Training is the development of knowledge, skills, and abilities obtained as one operates the system represented by the model.

b) Transportations - Traffic engineers employ simulation to test these adjustments for just this reason. It is far better to see the results in a simulation and watch traffic back up there than it is to have hundreds of frustrated motorists wasting valuable time traveling at a speed far below their expectation.

c) Business - It can be defined as a system of business endeavors within a particular business environment created to provide products and services to customers. Here are some of the core research areas:

i. M & S in Manufacturing Enterprise Engineering (M & S - MEE) addresses research on design, planning, and control of operations in manufacturing enterprises. Contributions extend the range of analytical and computational techniques addressed to these systems, and novel models offering policy knowledge of applicable solutions in manufacturing environments.

ii. M & S in Operations Research (M & S - OR) addresses research on progress in the structures and properties of models and procedures derived from studying operations. The focus of the cluster is on researching, creating, and/or improving analytical and computational techniques while emphasizing the relevance of the work in significant applications.

iii. M & S in Service Enterprise Engineering (M & S - SEE) addresses research on design, planning, and control of operations and processes in commercial and institutional service enterprises. As in M&S-MEE, contributions extend the range of analytical and computational methods addressed to these systems and novel models offering policy knowledge of applicable solutions. Research areas include: supply chain management, health care operations, retailing, and hospitality.

d) Medical - assist many fields within the medical profession including training, treatment, and disease modeling which targeted some of core areas such as Improved Training of Medical Professionals and Improve Treatment.

2.2.3. Advantages and disadvantages

According to Banks (2009), there are advantages and disadvantages in using modeling and simulation (M&S) listed by the Institute of Industrial Engineers (IIE) in 1998. Some of the advantages to using modeling and simulation are as follows:

a) The ability to choose correctly by testing every aspect of a proposed change without committing additional resources.
b) Compress and expand time to allow the user to speed up or slow-down behavior or phenomena to facilitate in-depth research.
c) Understand why by reconstructing the scenario and examining the scenario closely by controlling the system.

d) Explore possibilities in the context of policies, operating procedures, methods without disrupting the actual or real system.
e) Diagnose problems by understanding the interaction among variables that make up complex systems.
f) Identify constraints by reviewing delays on process, information, materials to ascertain whether or not the constraint is the effect or cause.
g) Develop understanding by observing how a system operates rather than predictions about how it will operate.
h) Visualize the plan with the use of animation to observe the system or organization actually operating.
i) Build consensus inferences for an objective opinion because M&S can avoid.
j) Prepare for change by answering the "what if" in the design or modification of the system.
k) Invest wisely because a simulated study costs much less than the cost of changing or modifying a system.
l) Better training can be done less expensively and with less disruption than on-the-job training.
m) Specify requirements for a system design that can be modified to reach the desired goal.

Besides having such numerous advantages, the IIE also made note of some of the disadvantages to using M&S such as:

a) The special training needed for building models
b) The difficulty in interpreting results when the observation may be the result of system inter-relationships or randomness.
c) Cost in money and time due to the fact that simulation modeling and analysis can be time consuming and expensive
d) Inappropriate use of modeling and simulation when an analytical solution is best.